Lagrangian Studies of Submesoscale Coherent Vortices in the California Current System

Curtis A. Collins, Newell Garfield, and Robert Paquette
Department of Oceanography
Naval Postgraduate School
833 Dyer Road, Bldg 232, Rm 328
Monterey, CA 93943-5122
Phone: (831) 656-3271 Fax: (831) 656-2712 Email: collins@oc.nps.navy.mil

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http://www.nps.navy.mil/

LONG-TERM GOALS

Our long-term goal is to understand the kinematics and dynamics of the California Current System and to apply this knowledge to naval and maritime operations in Eastern Boundary Current regions.

SCIENTIFIC OBJECTIVES

Along the Central and Northern California coast, subsurface floats routinely encounter submesoscale coherent vortices. The occurrence of these vortices is common enough that they have an important role in the offshore transport of properties from the coastal zone to the deep sea. The specific objectives of this study are to determine (1) when, where and how these vortices are formed, and (2) their role in mixing and transporting equatorial and subarctic waters.

APPROACH

Our goals are accomplished through the collection of shipboard CTD and ADCP data in the Central California area, moored observations of currents, and subsurface (RAFOS) float measurements. This project launched RAFOS floats in conjunction with mesoscale-resolving hydrographic surveys of the California Current off Central California.

WORK COMPLETED

Triads of RAFOS floats were launched in poleward flow over the outer continental slope between 35°N and 36°N in November 1999, July and September, 2000. Seven floats that were launched in 1997 and two floats that were launched in 1998 surfaced. These data were processed and the floats navigated. Sources off Pt. Arguello, Moss Landing, and Cape Mendocino were monitored using the NPS Ocean Acoustic Observatory at Point Sur. A new source was placed on Hoke seamount in May 2000 and is also monitored at Point Sur.

Results from 1992-5 (Garfield et al., 1999) have been updated to include 1996-8 trajectories and have been accepted for publication (Garfield et al., 2000). The latter manuscript also includes a comparison with numerical trajectories generated by an eddy resolving ocean circulation model.

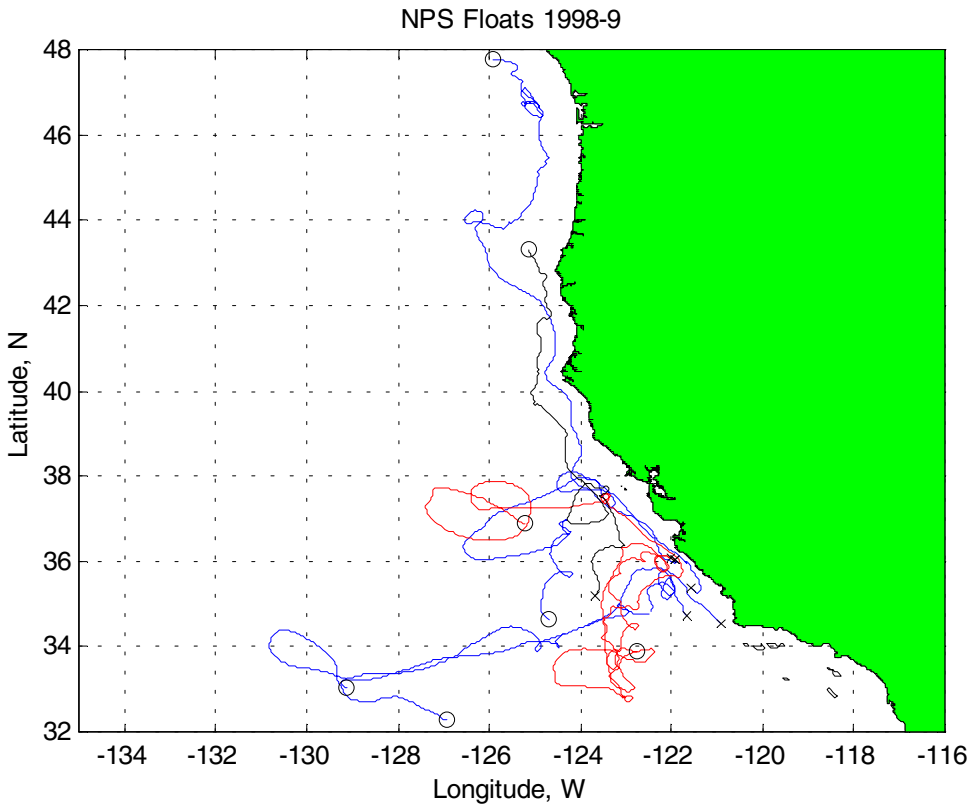

Figure 1. Trajectories for NPS RAFOS floats, 1998-1999. Blue trajectories are for floats that were launched in May 1998, red trajectories for November 1998, and the black trajectory for May 1999. "x" indicates launch locations and "o" indicates surfacing location.

RESULTS

During the period 1992-1998, 38 isobaric RAFOS floats were deployed to sample the subsurface flow over the continental margin off Central California. The deployments have shown robust year-round poleward flow. Two other types of flow have also been seen: a region of weak flow with little net displacement just west of the slope, and an active westward propagating eddy field. This eddy field appears to be the primary mechanism for moving floats from the slope into the ocean interior. Observations and statistics from the floats were compared to Lagrangian estimates of particles tracked in a global high resolution ocean simulation in order to evaluate the fidelity of the model along an eastern boundary. Results show that the model reproduces the general character of the flow reasonably well, but underestimates both the mean and eddy energies by a substantial amount.

Figure 1 shows the trajectories for all floats that were tracked during the past year. These floats were launched to south of Point Sur but exhibited patterns similar to those for floats launched off San Francisco. Two of the floats moved poleward along the continental slope, but one of these was launched almost 200 km from the upper slope. Three of the floats launched in May 1998 also moved onshore at the beginning of their trajectories, then two of these subsequently moved offshore along nearly the same zonal path near 34°N about two weeks apart. The two floats launched in November 1998 first moved poleward along the slope for a short distance, then moved offshore and southward

together. But one subsequently returned to the slope in June 1999, moving poleward to about 37.5°N before moving offshore again.

Since we began our search for submesoscale eddies, we have been remarkably successful in not finding them. We have placed our floats in nearshore waters of equatorial origin to the south of Point Sur where the persistent poleward flow crosses a number of submarine canyons. The geography of Point Sur is similar to the meddy formation region in the Atlantic, and the interaction of flow along the slope with canyons was similar to conditions reported for eddy formation in the Arctic. Only one of the floats (red in Figure 1) appeared to have successfully sampled an eddy over an extended period, spending about 150 days within the eddy.

The floats that surfaced last year were the first re-sealable floats that we deployed. These floats incorporated a number of engineering improvements and did not leak. At the completion of the mission, these floats broadcast the data that they have collected in a repeatable psuedo-random sequence. For optimum return of data, it is important that the product of the number of messages times the message repetition rate not equal the number of seconds in a day.

IMPACT/APPLICATIONS

The view of the interior flow field for the eastern boundary derived from these float trajectories is markedly different from that presented in most text books. There is no California Current. The eddy field provides an important mechanism for transport of water from near the coast to the interior of the Northeastern Pacific Ocean, while the poleward flow transports equatorial and subtropical waters poleward into the subpolar gyre, where they serve as source waters for coastal upwelling.

TRANSITIONS

The techniques and methods used to analyze these data have been applied to the development of tactical decision aids for mine warfare.

RELATED PROJECTS

Related projects involve analysis of shipboard observations of oceanographic conditions along CalCOFI line 67, participation in Central California cruises sponsored by the Naval Oceanographic Office, California Current tomography as part of the activities of the Ocean Acoustic Federation, and the use of RAFOS floats to track hydrothermal plumes in the region of Juan de Fuca Ridge. We collaborated with scientists at LANL to study the behavior of “numerical” floats in their high resolution numerical ocean model.

PUBLICATIONS

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